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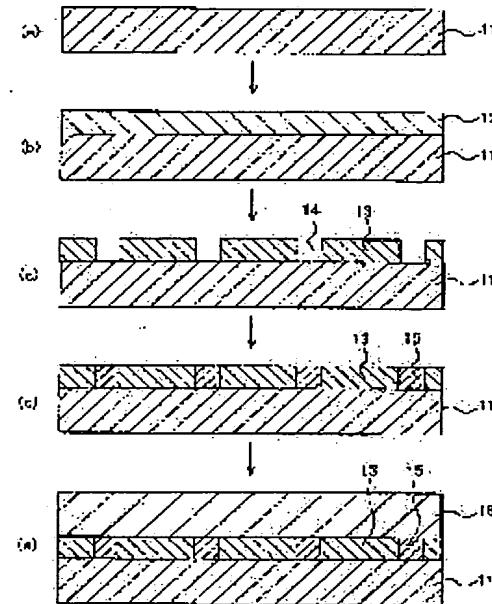
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(54) OPTICAL WAVEGUIDE SUBSTRATE, METHOD OF MANUFACTURING THE SAME, OPTICAL WAVEGUIDE PARTS AND METHOD OF MANUFACTURING THE SAME

(57)Abstract:

PROBLEM TO BE SOLVED: To provide the structure of an optical waveguide substrate having cores in a fine pattern which hardly cause decrease in transfer accuracy during forming the cores due to thermal expansion and a method of manufacturing the optical waveguide substrate.

SOLUTION: A UV-curing resin 12 is applied onto a lower clad layer 11 made of a planar glass substrate. The UV-curing resin 12 is hardened by irradiation with UV rays through the back face of a die which has linear projections of the core pattern and transmits UV rays so as to form an intermediate clad layer 13 having grooves 14. Then the grooves 14 are filled with a transparent resin having a different refractive index to form the cores 15. Then an upper clad layer 17 made of a planar glass substrate is fixed thereto to manufacture the optical waveguide substrate.



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CLAIMS

[Claim(s)]

[Claim 1] Are the manufacture approach of the optical waveguide substrate which restrains a light beam by incore and is made to spread in accordance with the shaft of said core, and the glass substrate of a refractive index n1 is processed into a predetermined configuration. The process which obtains the lower cladding layer which makes one flat surface an optical plane of composition, and the process which applies to the optical plane of composition of said lower cladding layer the ultraviolet-rays hardening resin which has a refractive index n2, the line which has the same configuration as said core — the mold which penetrates the ultraviolet rays in which heights were formed — using — said ultraviolet-rays hardening resin — pressing — said type of line — with the process which makes heights contact the optical plane of composition of said lower cladding layer. The process which obtains the middle cladding layer in which the slot which releases said mold from mold and serves as space of said core after stiffening said ultraviolet-rays hardening resin by irradiating ultraviolet rays from said type of rear face was formed. Said slot of said middle cladding layer is filled up with the transparency resin which has a refractive index n3 ($n3 > n2, n1$). The manufacture approach of the optical waveguide substrate characterized by having the process which forms an up cladding layer in the top face of the process which obtains said core by making it harden, and said middle cladding layer after said core was formed by joining the flat-surface glass substrate which has a refractive index n4 ($n4 < n3$).

[Claim 2] The lower cladding layer which is the optical waveguide substrate which restrains a light beam by incore and is made to spread in accordance with the shaft of said core, and consists of a flat-surface glass substrate of a refractive index n1, The middle cladding layer in which the slot which is pinched by the up cladding layer which consists of a flat-surface glass substrate of a refractive index n4, and said lower cladding layer and said up cladding layer, consists of ultraviolet-rays hardening resin which has a refractive index n2, and serves as space of said core was established. The optical waveguide substrate characterized by having said core which the slot of said middle cladding layer was made to fill up with and harden the transparency resin which has a refractive index n3 ($n3 > n4, n2, n1$), and was obtained.

[Claim 3] Are the manufacture approach of optical waveguide components of combining the optical waveguide substrate which restrains a light beam by incore and is made spreading in accordance with the shaft of said core, and an optical fiber, and the glass substrate of a refractive index n1 is processed into a predetermined configuration. the line for forming the process which obtains the glass substrate for [fabricated] which makes one flat surface an optical plane of composition, and the fixed slot of said optical fiber, while pressing said glass substrate for [fabricated] using the press die in which the crest type projection was formed While making it soften by heating said glass substrate for [fabricated] and forming said fixed slot in said some of glass substrates for [fabricated]. The process which forms a lower cladding layer in other parts of said glass substrate for [fabricated]. The process which applies to the top face of the lower cladding layer of said glass substrate for [fabricated] the ultraviolet-rays hardening resin which has a refractive index n2. The mold which penetrates the ultraviolet rays in which heights were formed is used. the line which has the same configuration as said core — said line — the center line of the fixed slot of heights and said optical fiber is in agreement — as — said ultraviolet-rays hardening resin — pressing — said type of line — with the process which makes heights contact the flat-surface part of the lower cladding layer of said glass substrate for [fabricated]. The process which obtains the middle cladding layer in which the slot which opens said mold wide and serves as space of said core after stiffening said ultraviolet-rays hardening resin by irradiating ultraviolet rays from said type of rear face was formed. The process which obtains said core by making the slot of said middle cladding layer fill up with and harden the transparency resin which has a refractive index n3 ($n3 > n2, n1$). The manufacture approach of the optical waveguide components characterized by having the process which forms an up cladding layer in the top face of the middle cladding layer after said core was formed by joining the flat-surface glass substrate which has a refractive index n4 ($n4 < n3$).

[Claim 4] They are the optical waveguide components which combine the optical waveguide substrate which restrains a light beam by incore and is made to spread in accordance with the shaft of said core, and an optical fiber. The lower cladding layer which consists of a glass substrate of a refractive index n1 and by which the optical plane of composition was formed in said some of glass substrates, and the base substrate which has the optical fiber joint by which the fixed slot of said optical fiber was formed in other parts of said glass substrate. The middle cladding layer by which it was prepared in the optical plane of composition of the lower cladding layer of said base substrate, and the slot which consists of ultraviolet-rays hardening resin which has a refractive index n2, and serves as space of said core was prepared on the production of the fixed slot of said optical fiber. Said core which the slot of said middle cladding layer was made to fill up with and harden the transparency resin which has a refractive index n3 ($n3 > n2, n1$), and was obtained. The optical waveguide components characterized by having the up cladding layer which joined the flat-surface glass substrate which has a refractive index n4 ($n4 < n3$) to said core and top face of a middle cladding layer, and was formed in them.

[Claim 5] Are the manufacture approach of the optical waveguide substrate which restrains a light beam by incore and is made to spread in accordance with the shaft of said core, and the glass substrate of a refractive index n1 is processed into a predetermined configuration. The process which obtains the lower cladding layer which makes one flat surface an optical plane of composition, and the process which applies to the optical plane of composition of said lower cladding layer the ultraviolet-rays hardening resin which has a refractive index n2 ($n2 > n1$), the line which has the same configuration as said core — the mold which penetrates the ultraviolet rays in which the crevice was formed — using — said ultraviolet-rays hardening resin — pressing — said type of line — with the process which makes the flat-surface section except a crevice contact the optical plane of composition of said lower cladding layer. By stiffening said ultraviolet-rays hardening resin and opening said mold from a press condition by irradiating ultraviolet rays from said type of rear face. The process which forms said core in the top face of said

lower cladding layer, and by applying and stiffening the transparency resin which has a refractive index n_3 ($n_3 < n_2$) so that said core may be wrapped in The manufacture approach of the optical waveguide substrate characterized by having the process which forms a plate-like up cladding layer, and the process which forms the flat-surface glass substrate for protection in the top face of said up cladding layer.

[Claim 6] The lower cladding layer which is the optical waveguide substrate which restrains a light beam by incore and is made to spread in accordance with the shaft of said core, and consists of a flat-surface glass substrate of a refractive index n_1 . Said core formed in the top face of said lower cladding layer convex using the ultraviolet-rays hardening resin which has a refractive index n_2 ($n_2 > n_1$). The optical waveguide substrate characterized by having the up cladding layer formed in plate-like by applying and stiffening the transparency resin which has a refractive index n_3 ($n_3 < n_2$) so that said core may be wrapped in, and the flat-surface glass substrate for protection formed in the top face of said up cladding layer.

[Claim 7] Are the manufacture approach of optical waveguide components of combining the optical waveguide substrate which restrains a light beam by incore and is made spreading in accordance with the shaft of said core, and an optical fiber, and the glass substrate of a refractive index n_1 is processed into a predetermined configuration. the line for forming the process which obtains the glass substrate for [fabricated] which makes one flat surface an optical plane of composition, and the fixed slot of said optical fiber, while pressing said glass substrate for [fabricated] using the press die in which the crest type projection was formed While making it soften by heating said glass substrate for [fabricated] and forming the fixed slot of said optical fiber in said some of glass substrates for [fabricated] The process which forms a lower cladding layer in other parts of said glass substrate for [fabricated]. The process which applies to the top face of the lower cladding layer of said glass substrate for [fabricated] the ultraviolet-rays hardening resin which has a refractive index n_2 ($n_2 > n_1$). The mold which penetrates the ultraviolet rays in which the crevice was formed is used. the line which has the same configuration as said core — said line — said ultraviolet-rays hardening resin being pressed so that the center line of a crevice and the fixed slot of said optical fiber may be in agreement, and with the process which makes the flat-surface section except said type of crevice contact the top face of said lower cladding layer By stiffening said ultraviolet-rays hardening resin and opening said mold from a press condition by irradiating ultraviolet rays from said type of rear face The process which forms said core in the top face of said lower cladding layer, and by applying the transparency resin which has a refractive index n_3 ($n_3 < n_2$) so that said core may be wrapped in The manufacture approach of the optical waveguide components characterized by having the process which forms a plate-like up cladding layer, and the process which forms the flat-surface glass substrate for protection in the top face of said up cladding layer.

[Claim 8] They are the optical waveguide components which combine the optical waveguide substrate which restrains a light beam by incore and is made to spread in accordance with the shaft of said core, and an optical fiber. The lower cladding layer which consists of a glass substrate of a refractive index n_1 and by which the optical plane of composition was formed in said some of glass substrates, and the base substrate which has the optical fiber joint by which the fixed slot of said optical fiber was formed in other parts of said glass substrate. Said core formed in convex so that it might be prepared in the top face of the lower cladding layer of said base substrate, and it might consist of ultraviolet-rays hardening resin which has a refractive index n_2 ($n_2 > n_1$) and might be in agreement with the production of the fixed slot of said optical fiber. By applying and stiffening the resin which has a refractive index n_3 ($n_3 < n_2$) so that said core may be wrapped in The optical waveguide components characterized by having the up cladding layer formed in plate-like, and the flat-surface glass substrate for protection formed by joining a glass substrate to the top face of said up cladding layer.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Field of the Invention] This invention relates to the optical waveguide component for it being highly precise and connecting a reliable optical waveguide substrate and its reliable manufacture approach, and an optical fiber which can be manufactured by the cheap approach, and its manufacture approach.

[0002]

[Description of the Prior Art] Drawing 13 is the sectional view showing the structure of the optical waveguide substrate of a general quartz system single mode. It is shown to a light beam to this optical waveguide substrate at the part of core 122a with a refractive index higher than the lower cladding layer 121 and the up cladding layer 123, and it has composition which a light beam spreads to the shaft orientations of optical waveguide.

[0003] Such a manufacture approach of the conventional optical waveguide substrate is explained using drawing 14. As shown in drawing 14 (a), the flame depositing method etc. is used on the quartz substrate which served as the lower cladding layer 121, the optical material 122 with a refractive index higher than the lower cladding layer 121 is formed, and it changes into a condition like drawing 14 (b). Next, by the dry etching method, an optical material 122 is processed into the pattern of a predetermined core, and core 122a is formed in the photograph RISOGURAFU method list like drawing 14 (c). Finally, as shown in drawing 14 (d), the method of wrap up cladding layer 123 is formed, and an optical waveguide substrate is made to core 122a, as the bibliography which indicated such a manufacture approach -- the Kawachi work, optronics, and No. -- there are 8, 85, and 1988 grades.

[0004] On the other hand, shaping is easy although the penetrable ability and dependability of light are inferior in a resin ingredient compared with a quartz. For this reason, the optical waveguide substrate using resin is also examined in order to attain low cost-ization of an optical waveguide substrate. The manufacture approach of the optical waveguide substrate made of resin carries out sequential formation of a cladding layer and the core layer, like manufacture of the optical waveguide substrate made from a quartz, carries out patterning of the core by the dry etching method, and manufactures it.

[0005] However, when a FOTORISO graphic method and the dry etching method are used for patterning of a core, much complicated and highly precise facilities are needed. Therefore, in having manufactured the optical waveguide substrate by such approach, although the ingredient is cheap, it is difficult to manufacture an optical waveguide substrate cheaply substantially.

[0006] Recently, the manufacture approach of an optical waveguide substrate as shown in drawing 15 is used as indicated by JP,8-320420,A. By this manufacture approach, as shown in drawing 15 (a), using the moldings 131-ed which consists of thermoplastics like glass, heating softening of this is carried out and it is made plate-like. Next, as shown in drawing 15 (b), press forming is carried out by the press die which has the reversal configuration (heights) of a core pattern, and a moldings is taken out after cooling. If it carries out like this, the imprint of a core pattern will be performed and crevice 131a will be formed. In order to use this plate-like member as an optical waveguide substrate, as shown in drawing 15 (c), the resin 132 with which refractive indexes differ is embedded at crevice 131a. Next, as shown in drawing 15 (d), the substrate used as the up cladding layer 133 is formed in the top face of the lower cladding layer 134, and an optical waveguide substrate is produced.

[0007]

[Problem(s) to be Solved by the Invention] However, by such imprint approach, since the moldings-ed which carried out heating softening is contacted to a press die and it cools, it originates in the difference of the coefficient of thermal expansion of a moldings-ed and a press die, and thermal stress occurs. Consequently, the precision of the pattern imprinted by the moldings-ed falls. A pattern gap becomes large, so that distance becomes long towards the core of a press die to a periphery especially. Since the coefficient of thermal expansion is large figures about double [1-] compared with ingredients, such as a quartz used as an ingredient of a mold, especially when a resin ingredient is used for a moldings-ed, when severe, a resin ingredient comes to be scooped out by the press die.

[0008] If it imprints to a resin substrate using a press die according to the place which this invention person actually examined concretely, the shape of breadth and a quirk will have been confused by the width of face of a slot on the level of micron order. It is thought that this phenomenon is the result of a resin substrate's contracting more greatly than a press die at the time of cooling, and a resin substrate contracting toward that imprint center section. Thus, the resin ingredient had the advantage which can be fabricated at low temperature, and although the manufacturing-cost top was also advantageous, when it was going to imprint the pattern by press forming, it had a problem of it becoming impossible to imprint a detailed pattern correctly.

[0009] Moreover, when the whole optical waveguide substrate was constituted from resin, since the coefficient of thermal expansion was large, the optical waveguide pattern deformed by the surrounding temperature change, and the technical problem that dependability was no longer secured enough occurred.

[0010] Without being made in view of such a conventional trouble, and using the fabricating method between the conventional heat, this invention uses ultraviolet-rays hardening resin for a middle cladding layer or a core, prevents the fall of the imprint precision resulting from thermal expansion, and aims at realizing the optical waveguide components and those manufacture approaches for connecting the optical waveguide substrate and optical fiber which have the core of a detailed pattern.

[0011]

[Means for Solving the Problem] The optical waveguide substrate of this invention is an optical waveguide substrate which restrains a light beam by incore and is made to spread in accordance with the shaft of said core. Moreover, the optical waveguide components of this invention are optical waveguide components which combine the optical waveguide substrate which restrains a light beam by incore and is made to spread in accordance with the shaft of said core, and an optical fiber. The manufacture

approach of this invention is an approach of manufacturing those optical waveguide substrates or optical waveguide components.

[0012] The manufacture approach of the 1st optical waveguide substrate of this invention processes the glass substrate of a refractive index n1 into a predetermined configuration. The process which obtains the lower cladding layer which makes one flat surface an optical plane of composition, and the process which applies to the optical plane of composition of said lower cladding layer the ultraviolet-rays hardening resin which has a refractive index n2, the line which has the same configuration as said core — the mold which penetrates the ultraviolet rays in which heights were formed — using — said ultraviolet-rays hardening resin — pressing — said type of line — with the process which makes heights contact the optical plane of composition of said lower cladding layer. The process which obtains the middle cladding layer in which the slot which releases said mold from mold and serves as space of said core after stiffening said ultraviolet-rays hardening resin by irradiating ultraviolet rays from said type of rear face was formed. Said slot of said middle cladding layer is filled up with the transparency resin which has a refractive index n3 (n3>n2, n1). It has the process which forms an up cladding layer in the top face of the process which obtains said core, and said middle cladding layer after said core was formed by joining the flat-surface glass substrate which has a refractive index n4 (n4< n3) by making it harden.

[0013] The lower cladding layer which the 1st optical waveguide substrate of this invention becomes from the flat-surface glass substrate of a refractive index n1, The middle cladding layer in which the slot which is pinched by the up cladding layer which consists of a flat-surface glass substrate of a refractive index n4, and said lower cladding layer and said up cladding layer, consists of ultraviolet-rays hardening resin which has a refractive index n2, and serves as space of said core was established, It has said core which the slot of said middle cladding layer was made to fill up with and harden the transparency resin which has a refractive index n3 (n3>n4, n2, n1), and was obtained.

[0014] The manufacture approach of the 1st optical waveguide component of this invention processes the glass substrate of a refractive index n1 into a predetermined configuration. the line for forming the process which obtains the glass substrate for [fabricated] which makes one flat surface an optical plane of composition, and the fixed slot of said optical fiber, while pressing said glass substrate for [fabricated] using the press die in which the crest type projection was formed While making it soften by heating said glass substrate for [fabricated] and forming said fixed slot in said some of glass substrates for [fabricated] The process which forms a lower cladding layer in other parts of said glass substrate for [fabricated]. The process which applies to the top face of the lower cladding layer of said glass substrate for [fabricated] the ultraviolet-rays hardening resin which has a refractive index n2, The mold which penetrates the ultraviolet rays in which heights were formed is used. the line which has the same configuration as said core — said line — the center line of the fixed slot of heights and said optical fiber is in agreement — as — said ultraviolet-rays hardening resin — pressing — said type of line — with the process which makes heights contact the flat-surface part of the lower cladding layer of said glass substrate for [fabricated]. The process which obtains the middle cladding layer in which the slot which opens said mold-wide and serves as space of said core after stiffening said ultraviolet-rays hardening resin by irradiating ultraviolet rays from said type of rear face was formed, The process which obtains said core by making the slot of said middle cladding layer fill up with and harden the transparency resin which has a refractive index n3 (n3>n2, n1), It has the process which forms an up cladding layer in the top face of the middle cladding layer after said core was formed by joining the flat-surface glass substrate which has a refractive index n4 (n4< n3).

[0015] The 1st optical waveguide component of this invention consists of a glass substrate of a refractive index n1. The lower cladding layer by which the optical plane of composition was formed in said some of glass substrates, and the base substrate which has the optical fiber joint by which the fixed slot of said optical fiber was formed in other parts of said glass substrate, The middle cladding layer by which it was prepared in the optical plane of composition of the lower cladding layer of said base substrate, and the slot which consists of ultraviolet-rays hardening resin which has a refractive index n2, and serves as space of said core was prepared on the production of the fixed slot of said optical fiber, It has the up cladding layer which joined the flat-surface glass substrate which has a refractive index n4 (n4< n3) to said core which the slot of said middle cladding layer was made to fill up with and harden the transparency resin which has a refractive index n3 (n3>n2, n1), and was obtained, said core, and the top face of a middle cladding layer, and was formed in them.

[0016] The manufacture approach of the 2nd optical waveguide substrate of this invention processes the glass substrate of a refractive index n1 into a predetermined configuration. The process which obtains the lower cladding layer which makes one flat surface an optical plane of composition, and the process which applies to the optical plane of composition of said lower cladding layer the ultraviolet-rays hardening resin which has a refractive index n2 (n2>n1), the line which has the same configuration as said core — the mold which penetrates the ultraviolet rays in which the crevice was formed — using — said ultraviolet-rays hardening resin — pressing — said type of line — with the process which makes the flat-surface section except a crevice contact the optical plane of composition of said lower cladding layer By stiffening said ultraviolet-rays hardening resin and opening said mold from a press condition by irradiating ultraviolet rays from said type of rear face The process which forms said core in the top face of said lower cladding layer, and by applying and stiffening the transparency resin which has a refractive index n3 (n3< n2) so that said core may be wrapped in It has the process which forms a plate-like up cladding layer, and the process which forms the flat-surface glass substrate for protection in the top face of said up cladding layer.

[0017] The lower cladding layer which the 2nd optical waveguide substrate of this invention becomes from the flat-surface glass substrate of a refractive index n1, Said core formed in the top face of said lower cladding layer convex using the ultraviolet-rays hardening resin which has a refractive index n2 (n2>n1), It has the up cladding layer formed in plate-like, and the flat-surface glass substrate for protection formed in the top face of said up cladding layer by applying and stiffening the transparency resin which has a refractive index n3 (n3< n2) so that said core may be wrapped in.

[0018] The manufacture approach of the 2nd optical waveguide component of this invention processes the glass substrate of a refractive index n1 into a predetermined configuration. the line for forming the process which obtains the glass substrate for [fabricated] which makes one flat surface an optical plane of composition, and the fixed slot of said optical fiber, while pressing said glass substrate for [fabricated] using the press die in which the crest type projection was formed While making it soften by heating said glass substrate for [fabricated] and forming the fixed slot of said optical fiber in said some of glass substrates for [fabricated] The process which forms a lower cladding layer in other parts of said glass substrate for [fabricated]. The process which applies to the top face of the lower cladding layer of said glass substrate for [fabricated] the ultraviolet-rays hardening resin which has a refractive index n2 (n2>n1), The mold which penetrates the ultraviolet rays in which the crevice was formed is used. the line which has the same configuration as said core — said line — said ultraviolet-rays hardening resin being pressed so that the center line of a crevice and the fixed slot of said optical fiber may be in agreement, and with the process which makes the flat-surface section except said type of crevice contact the top face of said lower cladding layer By stiffening said

ultraviolet-rays hardening resin and opening said mold from a press condition by irradiating ultraviolet rays from said type of rear face. The process which forms said core in the top face of said lower cladding layer, and by applying the transparency resin which has a refractive index n_3 ($n_3 < n_2$) so that said core may be wrapped in it has the process which forms a plate-like up cladding layer, and the process which forms the flat-surface glass substrate for protection in the top face of said up cladding layer.

[0019] The 2nd optical waveguide component of this invention consists of a glass substrate of a refractive index n_1 . The lower cladding layer by which the optical plane of composition was formed in said some of glass substrates, and the base substrate which has the optical fiber joint by which the fixed slot of said optical fiber was formed in other parts of said glass substrate. Said core formed in convex so that it might be prepared in the top face of the lower cladding layer of said base substrate, and it might consist of ultraviolet-rays hardening resin which has a refractive index n_2 ($n_2 > n_1$) and might be in agreement with the production of the fixed slot of said optical fiber. By applying and stiffening the resin which has a refractive index n_3 ($n_3 < n_2$) so that said core may be wrapped in, it has the up cladding layer formed in plate-like, and the flat-surface glass substrate for protection formed by joining a glass substrate to the top face of said up cladding layer.

[0020]

[Embodiment of the Invention] Hereafter, it explains, referring to a drawing about the gestalt of each operation of this invention.

[0021] (Gestalt 1 of operation) The structure and its manufacture approach of the optical waveguide substrate in the gestalt 1 of operation of this invention are explained using drawing 1 – drawing 4. An optical waveguide substrate restrains a light beam by incore, and is made to spread it in accordance with the shaft of a core. Drawing 1 is outline process drawing of the manufacture approach of the optical waveguide substrate in the gestalt of this operation. As shown in drawing 1 (a), the lower cladding layer 11 which consists of a flat-surface glass substrate of a refractive index n_1 is fixed horizontally, and as shown in drawing 1 (b), ultraviolet-rays hardening resin 12 is applied to the top face which is an optical plane of composition of the lower cladding layer 11. This ultraviolet-rays hardening resin 12 has a refractive index n_2 .

[0022] next, the location equivalent to a core — a line — by creating beforehand the mold (not shown) which penetrates the ultraviolet rays which have heights, pressing ultraviolet-rays hardening resin 12 with the mold, and irradiating ultraviolet rays from the rear face of a mold, ultraviolet-rays hardening resin 12 is stiffened and a mold is released from mold. If it does so, as shown in drawing 1 (c), the middle cladding layer 13 which has the slot 14 equivalent to a core by the same thickness as a core will be formed. And as shown in drawing 1 (d), a slot 14 is filled up with the transparency resin of a refractive index n_3 ($n_3 > n_2, n_1$), and a core 15 is formed. The up cladding layer 16 which consists of a flat-surface glass substrate which moreover has a refractive index n_4 ($n_4 < n_3$) as shown in drawing 1 (e) is formed, and an optical waveguide substrate is completed.

[0023] Drawing 2 is the sectional view showing the black light 20 used for the hardening process of ultraviolet-rays hardening resin 12 in the manufacture approach of the gestalt this operation. Drawing 2 shows the condition before hardening. a line for the mold 21 which penetrates ultraviolet rays to form a core — it is the mold made from a quartz which has heights 21a. this line — in the example based on the gestalt of this operation, after heights 21a ground the quartz-glass substrate 5mm in thickness, and 5mm wide [5mm long and] at the flat surface, it was formed by the patterning method using the usual photoresist. the dry etching method after forming a band-like pattern to a quartz-glass substrate in the example — using — a quartz-glass substrate front face — a line — four heights 21a (cross-section configuration; projection with a height [of 8 micrometers] x width of face of 8 micrometers) was prepared at intervals of 250 micrometers.

[0024] On the other hand, the flat-surface glass substrate used as a lower cladding layer 11 is what was ground at the flat surface 2mm in thickness, and 5mm wide [5mm long and], and has the property of refractive-index $n_1=1.5$, and coefficient-of-thermal-expansion $70 \times 10^{-7}/K$. The ultraviolet-rays hardening resin 12 which has the refractive index n_2 same [11] as this lower cladding layer 11 was applied by the thickness of homogeneity by spin coating. Then, after applying a release agent to the mold 21 made from a quartz mentioned above, the mold 21 was carried on ultraviolet-rays hardening resin 12, and it placed on the bottom block 22.

[0025] In this condition, the upper block 23 which built in the light source 24 which generates ultraviolet rays was dropped gradually, and the pressure was applied and pressed. it is shown in drawing 3 — as — the line of the mold 21 made from a quartz — press is continued until it touches the front face of the lower cladding layer 11, and after the tip of heights 21a irradiated ultraviolet rays and stiffened ultraviolet-rays hardening resin 12 from the rear face of a mold 21, it made the mold 21 release from mold As the substrate at this time was shown in drawing 3 , on the lower cladding layer 11, it is the same thickness as a core and the middle cladding layer 13 which has a slot equivalent to a core was formed. In this substrate, it dissociates mutually with a core and the middle cladding layer 13 has band-like. Since the further band-like middle cladding layer 13 was firmly pasted up on the lower cladding layer 11, the pattern gap with a mold 21 and the middle cladding layer 13 became very small, and the configuration of a mold 21 was imprinted good as it was.

[0026] Then, as shown in drawing 1 (c) and (d), the transparency resin made from epoxy which has the refractive index n_3 higher about 0.3% than the middle cladding layer 13 was embedded in the formed slot 14, and the core 15 was formed in it like drawing 1 (d). And the up cladding layer 16 which consists of the same flat-surface glass substrate as the lower cladding layer 11 was further stuck from the upper part. Thus, the optical waveguide substrate shown in drawing 4 was produced.

[0027] This optical waveguide substrate used the epoxy resin as the core 15, made the flat-surface glass substrate the up cladding layer 16 and the lower cladding layer 11, and is equipped with ultraviolet-rays hardening resin as a middle cladding layer 13. Thus, with the flat-surface glass substrate of an up-and-down cladding layer, it has the core 15 which consists of transparency resin, and structure which puts the middle cladding layer 13 firmly. For this reason, it turned out that form status change-ization hardly arises by the temperature change of a perimeter environment. Therefore, it can be said that this optical waveguide substrate is equipped with sufficient practicality.

[0028] (Gestalt 2 of operation) The structure and its manufacture approach of the optical waveguide components in the gestalt 2 of the operation of this invention to a degree are explained using drawing 5 and drawing 6. Optical waveguide components are components which combine the optical waveguide substrate which restrains a light beam by incore and is made to spread in accordance with the shaft of a core, and an optical fiber. A press die (not shown) is first manufactured using a cemented carbide material. A press side which unifies the fixed slot of the shape of V character which fixes an optical fiber, and the flat-surface section (optical plane of composition) for forming an optical waveguide substrate is required for a press die. for this reason, two or more lines for forming a fixed slot — a crest type projection and a line — it is processed into a ***** material so that the flat-surface section which adjoined the crest type projection may be formed in coincidence. the example based on the gestalt of this operation — a dimension — 10mm in thickness, and 10mm by 5mm — carrying out — a line — four spacing of a crest type projection was formed by 250 micrometers. The precious alloy film was formed as a protective coat for mold release to the press side of this press die.

[0029] Next, as shown in drawing 5 (a), it fixes so that the glass substrate 50 for [fabricated] may be located under the press die (not shown) which prepared and mentioned above the glass substrate 50 (for example, refractive-index $n1=1.5$,mm [in 7/K, and thickness / 2], 10mm by [coefficient-of-thermal-expansion 70x10-7/K] 5mm) for [fabricated] for base substrates. Next, the glass substrate 50 for [fabricated] and a press die are heated, heating softening of the glass substrate 50 for [fabricated] is carried out at 700 degrees C, and press forming is performed. Consequently, as shown in drawing 5 (b), the fixed slot 51 of the shape of V character for fixing an optical fiber is formed as an optical fiber joint, and the base substrate 53 united with the flat-surface section 52 used as the optical plane of composition of a lower cladding layer is formed.

[0030] next, the line which is equivalent to a core part beforehand — the mold (not shown) which penetrates the ultraviolet rays which have heights is produced by the following approaches. For example, after grinding a quartz-glass substrate 5mm in thickness, and 5mm wide [5mm long and] at a flat surface, the pattern of a core part is formed by the patterning method using the usual photoresist, and the location which is the front face of a quartz-glass substrate and is equivalent to a core using the dry etching method — a line — four heights (cross-section configuration; projection with a height [of 8 micrometers] x width of face of 8 micrometers) are formed at intervals of 250 micrometers.

[0031] Next, as shown in drawing 5 (b) and (c), the ultraviolet-rays hardening resin 54 of a refractive index $n2$ ($n2=n1$) is applied to the flat-surface section 52 of the base substrate 53 by spin coating. And a release agent is applied to the front face of the mold which penetrates ultraviolet rays, and it installs in the black light 20 used for the hardening process of the ultraviolet-rays hardening resin shown in drawing 2 . this time — the center line of the fixed slot 51, and a line — the mold 21 which penetrates ultraviolet rays is fixed using a guide so that the center line of heights may be in agreement. In this condition, it installs between the upper block 23 and the bottom block 22, the upper block 23 is dropped gradually, and a pressure is applied and pressed. the line of the mold 21 as shown in drawing 2 — a press is continued until the tip of heights 21a touches the front face of the part used as the lower cladding layer 59 in the base substrate 53, as shown in drawing 5 (d).

[0032] And the light source 24 of the ultraviolet rays built in the upper block 23 is turned on from the rear face of a mold in the condition as it is, ultraviolet rays are irradiated, ultraviolet-rays hardening resin 54 is stiffened, and a mold 21 is made to release from mold. As shown in drawing 5 (d) as a result, the middle cladding layer 55 which has slot 55a equivalent to a core part by the same thickness as a core is formed in the top face of the lower cladding layer 59.

[0033] Then, to formed slot 55a, as shown in drawing 6 (e), rather than ultraviolet-rays hardening resin 54, a refractive index embeds the transparency resin of the epoxy which has the refractive index $n3$ high about 0.3%, and forms a core 56. Furthermore, from the upper part, as shown in drawing 6 (f), the flat-surface glass substrate of a refractive index $n4$ ($n4=n1$) is made into the condition of having coalesced the optical fiber joint and the optical waveguide substrate, as an up cladding layer 57 at lamination and the base substrate 53. Thus, the optical waveguide components which have an optical fiber joint, and the lower cladding layer 59, the middle cladding layer 55, a core 56 and the optical waveguide substrate that consists of an up cladding layer 57 were produced.

[0034] With the optical waveguide components produced by the manufacture approach of the gestalt this operation, it dissociated mutually through the core 56 and the band-like middle cladding layer 55 has pasted the lower cladding layer 59 firmly further. For this reason, the pattern gap by the differential shrinkage of the mold and the middle cladding layer 55 which penetrate ultraviolet rays, and the ingredient of a core 56 becomes very small, and can imprint the configuration of the mold which penetrates ultraviolet rays good as it is. And since alignment of the fixed slot 51 of the shape of V character for fixing an optical fiber is carried out to the core and high degree of accuracy of an optical waveguide substrate, it can build optical waveguide components into a splitter etc. easily only by arranging an optical fiber in a fixed slot.

[0035] (Gestalt 3 of operation) The structure and its manufacture approach of the optical waveguide substrate in the gestalt 3 of the operation of this invention to a degree are explained using drawing 7 – drawing 10 . Drawing 7 is process drawing showing the manufacture approach of an optical waveguide substrate. As shown in drawing 7 (a), the lower cladding layer 71 which consists of a flat-surface glass substrate of a refractive index $n1$ is prepared. Next, as shown in drawing 7 (b), the ultraviolet-rays hardening resin 72 of a refractive index $n2$ ($n2>n1$) is applied to the optical plane of composition of the lower cladding layer 71 by spin coating.

[0036] the location which is equivalent to a core part on the other hand — a line — the mold (not shown) which penetrates the ultraviolet rays in which the crevice was formed is prepared, ultraviolet-rays hardening resin 72 is pressed with a mold, from the rear face of a mold, ultraviolet rays are irradiated, ultraviolet-rays hardening resin is stiffened, and two or more mutually-independent bottom band-like cores 73 are formed like drawing 7 (c). Next, as shown in drawing 7 (d), the up cladding layer 74 is formed by applying the resin which has a refractive index $n3$ ($n3>n2$) so that the part of a core 73 may be wrapped in. And as shown in drawing 7 (e), the optical waveguide substrate of structure is obtained by joining the flat-surface glass substrate 75 for protection on the up cladding layer 74.

[0037] In the manufacture approach of the gestalt this operation, drawing 8 is the sectional view showing the structure of the black light 80 used for the hardening process of ultraviolet-rays hardening resin, and shows the condition before hardening. This black light 80 has the upper block 81 which can move up and down, and the block 82 under immobilization like the black light of the gestalt 1 of operation, and the light source 84 which generates ultraviolet rays is built in the upper block 81.

[0038] the location where the mold 83 which penetrates ultraviolet rays is equivalent to a core part — a line — it has crevice 83a, this line — in the example, after crevice 83a ground the quartz-glass substrate 5mm in thickness, and 5mm wide [5mm long and] at the flat surface, it was formed by the patterning method using the usual photoresist. moreover, the dry etching method after forming a band-like pattern to a quartz-glass substrate — using — a quartz-glass substrate front face — a line — four crevice 83a (cross-section configuration; projection with a depth [of 8 micrometers] x width of face of 8 micrometers) was prepared at intervals of 250 micrometers.

[0039] Next, the flat-surface glass substrate (refractive-index $n1=1.5$, coefficient-of-thermal-expansion 70x10-7/K, heat-resistant temperature of 700 degrees C) ground at the flat surface 2mm in thickness and 5mm wide [5mm long and] was prepared as a lower cladding layer 71, and was laid in the bottom block 82. And the refractive index applied to the top face of a flat-surface glass substrate the ultraviolet-rays hardening resin 72 which has the refractive index $n2$ higher about 0.3% than $n1$ by spin coating. Then, the mold 83 made from quartz glass mentioned above was put on the top face of ultraviolet-rays hardening resin 72. Drawing 8 shows this condition.

[0040] Next, the upper block 81 was dropped gradually, and the pressure was applied and pressed. Continued press until the tip of the mold 83 made from quartz glass touched the front face of the flat-surface glass substrate which forms the lower cladding layer 71, as shown in drawing 9 , and the light source of ultraviolet rays was made to turn on, and ultraviolet rays were irradiated from the rear face of a mold 83. The mold 83 was released from mold in the place which ultraviolet-rays hardening resin 72

hardened. As shown in drawing 7 (c) in this condition, four cores 73 were formed on the lower cladding layer 71. In the example, each core 73 was separated at intervals of 250 micrometers, and the lower cladding layer 71 was pasted further firmly. For this reason, the pattern gap with the mold 83 and core materials which penetrate ultraviolet rays was able to become very small, and was able to imprint the configuration of a mold 83 good as it was.

[0041] Then, the epoxy resin which has the same refractive index as the lower cladding layer 71 was applied so that a core 73 might be wrapped in, and it considered as the up cladding layer 74, and the optical waveguide substrate as shows the flat-surface glass substrate 75 for protection further to lamination and drawing 10 from the upper part was produced.

[0042] This optical waveguide substrate makes resin in the up cladding layer 74, makes a flat-surface glass substrate the lower cladding layer 71, uses ultraviolet-rays hardening resin as a core 73, and has further structure equipped with the flat-surface glass substrate 75 for protection on the up cladding layer 74. Thus, since the up cladding layer 74 which consists of an epoxy resin was firmly put with the up-and-down flat-surface glass substrate, it turned out that form status change-ization by the temperature change of a perimeter environment is hardly produced. Therefore, it can be said that this optical waveguide substrate is equipped with sufficient practicality.

[0043] (Gestalt 4 of operation) The structure and its manufacture approach of the optical waveguide components in the gestalt 4 of the operation of this invention to a degree are explained using drawing 11 and drawing 12. First, a press die (not shown) is manufactured using a cemented carbide material. A press side must be formed in a press die so that the fixed slot of the shape of V character for fixing an optical fiber and the flat-surface section for forming an optical waveguide substrate may be unified. as a mold [as opposed to / the press die prepared in the example processes it into a cemented carbide material, and / a fixed V character-like slot] — a line — the two or more crest type projection was formed, and the flat-surface section was formed further horizontally [the]. that in which the appearance of a press die has 10mm in thickness, and a 10mm long and 5mm wide dimension — carrying out — a line — four spacing of a crest type projection was formed by 250 micrometers. The precious alloy film was formed as a protective coat for mold release to the press side of this press die.

[0044] Next, as shown in drawing 11 (a), the glass substrate 110 (refractive-index $n1=1.5$, mm [in 7/K, and thickness / 2], 10mm by [coefficient-of-thermal-expansion 70×10^-6] 5mm) for [fabricated] was prepared, and was fixed under the press die mentioned above. And the press die was heated, heating softening of the glass substrate 110 for [fabricated] was carried out at 750 degrees C, and press forming was performed. Consequently, as shown in drawing 11 (b), the base substrate 113 with which the fixed slot 111 of the shape of V character for fixing an optical fiber and the flat-surface section 112 for forming an optical waveguide substrate were unified was formed.

[0045] next, the location which is equivalent to a core part beforehand — a line — the mold (not shown) which penetrates the ultraviolet rays which have a crevice was produced by the following approaches. After grinding the substrate of quartz glass 5mm in thickness, and 5mm wide [5mm long and] at a flat surface, the pattern used as a core partial fang furrow was formed by the patterning method using the usual photoresist, and the location which is the front face of a quartz-glass substrate and is equivalent to a core using the dry etching method — a line — four crevices (cross-section configuration; projection with a depth [of 8 micrometers] x width of face of 8 micrometers) were formed at intervals of 250 micrometers.

[0046] Next, as shown in drawing 11 (b) and (c), the ultraviolet-rays hardening resin 114 of the refractive index $n2$ higher about 0.3% than $n1$ was applied by spin coating on the flat-surface section 112 (optical plane of composition) of the base substrate 113, and a line — the release agent was applied to the front face of the mold which penetrates the ultraviolet rays which have a crevice, and it set in the black light 80 shown in drawing 8. At this time, the mold which penetrates ultraviolet rays so that the center line of the fixed slot 111 and the center line of a slot may be in agreement was fixed using the guide. In this condition, it laid in the top face of the bottom block 82, the upper block 81 was dropped gradually, and the pressure was applied and pressed. Press was continued until the apical surface of the mold 83 made from quartz glass shown in drawing 8 touched the front face of the part of the lower cladding layer 116 of the base substrate 113 shown in drawing 11 (d).

[0047] And in the condition as it is, the light source 84 of ultraviolet rays was made to turn on, from the rear face of the mold 83 made from quartz glass, ultraviolet rays were irradiated, ultraviolet-rays hardening resin 114 was stiffened, the core 115 was formed, and the mold 83 was released from mold. Consequently, as shown in drawing 11 (d), four cores 115 were formed in the optical plane of composition of the lower cladding layer 116.

[0048] To the whole substrate taken out successively, as shown in drawing 12 (e), the resin of the epoxy of the same refractive index $n3$ as the lower cladding layer 116 was applied so that a core 115 might be wrapped in, and the up cladding layer 117 was formed. Furthermore, the optical waveguide components which have the optical waveguide substrate which serves as an optical fiber joint from the lower cladding layer 116, a core 115, and the up cladding layer 117 in the flat-surface glass substrate 118 for protection as shown in lamination and drawing 12 (f) from the upper part were produced.

[0049] Four cores 115 were separated mutually and the optical waveguide components produced by the manufacture approach of the gestalt this operation are further pasted up on the lower cladding layer 116 firmly, as shown in drawing 12 (f). For this reason, the pattern gap with the mold and core materials which penetrate ultraviolet rays becomes very small, and can imprint the configuration of the mold which penetrates ultraviolet rays good as it is. And alignment of the fixed slot 111 of the shape of V character for fixing an optical fiber is carried out to the core of an optical waveguide substrate with high precision. For this reason, optical waveguide components are easily incorporable into a splitter etc. only by arranging an optical fiber in the fixed slot 111.

[0050]

[Effect of the Invention] According to this invention, between the mold which penetrates ultraviolet rays, and ultraviolet-rays hardening resin, since the pattern gap by the contraction generated at the hardening process of the ultraviolet-rays hardening resin by UV irradiation can be made remarkably small, formation of an efficient core pattern with a high precision is attained. Therefore, a cheap optical waveguide substrate and optical waveguide components can be manufactured efficiently. Moreover, form status change-ization of as opposed to change of ambient temperature in the optical waveguide substrate and optical waveguide components of this invention becomes small, and what has very high dependability is obtained.

[Translation done.]

* NOTICES *

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1. This document has been translated by computer. So the translation may not reflect the original precisely.
2. **** shows the word which can not be translated.
3. In the drawings, any words are not translated.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] The sectional view showing the outline process of the manufacture approach of the optical waveguide substrate in the gestalt 1 of operation of this invention

[Drawing 2] The outline sectional view showing the condition of having set the mold which penetrates ultraviolet rays in the black light used for manufacture of the optical waveguide substrate of the gestalt 1 of operation

[Drawing 3] The outline sectional view showing the condition that it was used for manufacture of the optical waveguide substrate of the gestalt 1 of operation, and the hardening process of ultraviolet-rays hardening resin was completed in the black light

[Drawing 4] The cross-section block diagram of the optical waveguide substrate manufactured by the manufacture approach of the gestalt 1 operation

[Drawing 5] The perspective view showing the outline process (the 1) of the manufacture approach of the optical waveguide components in the gestalt 2 of operation of this invention

[Drawing 6] The perspective view showing the outline process (the 2) of the manufacture approach of the optical waveguide components in the gestalt 2 of operation

[Drawing 7] The sectional view showing the outline process of the manufacture approach of the optical waveguide substrate in the gestalt 3 of operation of this invention

[Drawing 8] The outline sectional view showing the condition of having set the mold which penetrates ultraviolet rays in the black light used for manufacture of the optical waveguide substrate of the gestalt 3 of operation

[Drawing 9] The outline sectional view showing the condition that the hardening process of ultraviolet-rays hardening resin was completed, in the black light used for manufacture of the optical waveguide substrate of the gestalt 3 of operation

[Drawing 10] The cross-section block diagram of the optical waveguide substrate in the gestalt 3 of operation

[Drawing 11] The perspective view showing the outline process (the 1) of the manufacture approach of the optical waveguide components in the gestalt 4 of operation of this invention

[Drawing 12] The perspective view showing the outline process (the 2) of the manufacture approach of the optical waveguide components in the gestalt 4 of operation

[Drawing 13] The cross-section block diagram of the conventional common optical waveguide substrate

[Drawing 14] The sectional view showing the outline process of the manufacture approach of the conventional common optical waveguide substrate

[Drawing 15] The sectional view showing the outline process of the manufacture approach of the optical waveguide substrate by the conventional press forming

[Description of Notations]

11, 59, 71,116 Lower cladding layer

12, 54, 72,114 Ultraviolet-rays hardening resin

13 55 Middle cladding layer

14 55a Slot

15, 56, 73,115 Core

16, 57, 74,117 Up cladding layer

20 80 Black light

21 83 Mold which penetrates ultraviolet rays

21a a line — heights

22 82 Bottom block

23 81 Top block

50,110 Glass substrate for [fabricated]

51,111 Fixed slot

52,112 Flat-surface section

53,113 Base substrate

75,118 Flat-surface glass substrate for protection

83a a line — a crevice

[Translation done.]

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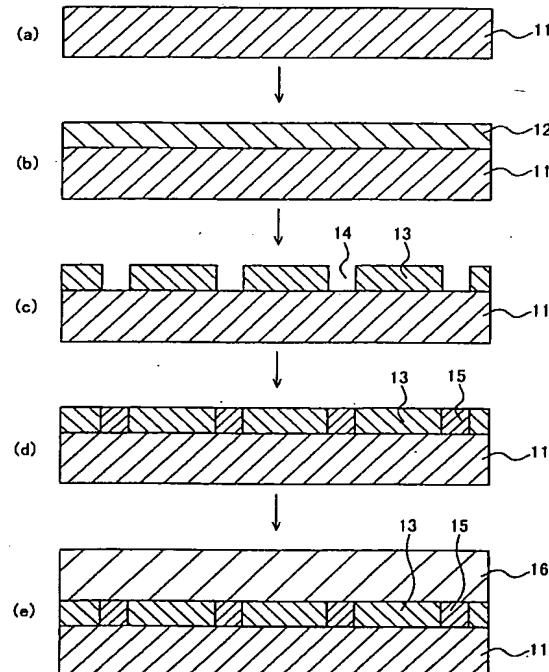
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(54)【発明の名称】光導波路基板とその製造方法、及び光導波路部品とその製造方法

(57)【要約】

【課題】コア成形時に熱膨張に起因する転写精度の低下を生じることのない、微細パターンのコアを有する光導波路基板の構成及び製造方法を提供する。

【解決手段】平面ガラス基板からなる下部クラッド層11上に、紫外線硬化樹脂12を塗布する。コア形状の線状凸部を有する紫外線を透過する型の裏面より紫外線を照射し、紫外線硬化樹脂12を硬化させ、溝部14を有する中間クラッド層13を形成する。次に屈折率の異なる透明樹脂を溝部14に充填し、コア15を形成する。そして、その上に平面ガラス基板からなる上部クラッド層17を固定し、光導波路基板を製作する。



【特許請求の範囲】

【請求項1】 光ビームをコア内で拘束して前記コアの軸に沿って伝搬させる光導波路基板の製造方法であって、
屈折率n1のガラス基板を所定形状に加工して、一方の平面を光学的接合面とする下部クラッド層を得る工程と、
前記下部クラッド層の光学的接合面に、屈折率n2を有する紫外線硬化樹脂を塗布する工程と、
前記コアと同一形状を有する線状凸部が形成された紫外線を透過する型を用いて前記紫外線硬化樹脂を押圧し、前記型の線状凸部を前記下部クラッド層の光学的接合面に当接させる工程と、
前記型の裏面より紫外線を照射することにより、前記紫外線硬化樹脂を硬化させた後、前記型を開放し、前記コアの空間となる溝部が形成された中間クラッド層を得る工程と、
前記中間クラッド層の前記溝部に、屈折率n3($n_3 > n_2, n_1$)を有する透明樹脂を充填して、硬化させることにより前記コアを得る工程と、
前記コアが形成された後の前記中間クラッド層の上面に、屈折率n4($n_4 < n_3$)を有する平面ガラス基板を接合することにより上部クラッド層を形成する工程とを有することを特徴とする光導波路基板の製造方法。

【請求項2】 光ビームをコア内で拘束して前記コアの軸に沿って伝搬させる光導波路基板であって、
屈折率n1の平面ガラス基板からなる下部クラッド層と、
屈折率n4の平面ガラス基板からなる上部クラッド層と、
前記下部クラッド層と前記上部クラッド層とに挟持され、屈折率n2を有する紫外線硬化樹脂からなり、前記コアの空間となる溝部が設けられた中間クラッド層と、
前記中間クラッド層の溝部に、屈折率n3($n_3 > n_4, n_2, n_1$)を有する透明樹脂を充填し硬化させて得た前記コアとを有することを特徴とする光導波路基板。

【請求項3】 光ビームをコア内で拘束して前記コアの軸に沿って伝搬させる光導波路基板と光ファイバとを結合させる光導波路部品の製造方法であって、
屈折率n1のガラス基板を所定形状に加工して、一方の平面を光学的接合面とする被成形用ガラス基板を得る工程と、
前記光ファイバの固定溝を形成するための線状山型突起が形成されたプレス型を用いて前記被成形用ガラス基板を押圧するとともに、前記被成形用ガラス基板を加熱することにより軟化させ、前記被成形用ガラス基板の一部に前記固定溝を形成するとともに、前記被成形用ガラス基板の他の部分に下部クラッド層を形成する工程と、
前記被成形用ガラス基板の下部クラッド層の上面に、屈折率n2を有する紫外線硬化樹脂を塗布する工程と、
前記コアと同一形状を有する線状凸部が形成された紫外線を透過する型を用いて、前記線状凸部と前記光ファイバの固定溝の中心線が一致するように前記紫外線硬化樹脂を押圧し、前記型の線状凸部を前記被成形用ガラス基板の下部クラッド層の平面部分に当接させる工程と、
前記型の裏面より紫外線を照射することにより前記紫外線硬化樹脂を硬化させた後、前記型を開放し、前記コアの空間となる溝部が形成された中間クラッド層を得る工程と、
前記中間クラッド層の溝部に、屈折率n3($n_3 > n_2, n_1$)を有する透明樹脂を充填して硬化させることにより前記コアを得る工程と、
前記コアが形成された後の中間クラッド層の上面に、屈折率n4($n_4 < n_3$)を有する平面ガラス基板を接合することにより上部クラッド層を形成する工程とを有することを特徴とする光導波路部品の製造方法。

【請求項4】 光ビームをコア内で拘束して前記コアの軸に沿って伝搬させる光導波路基板と光ファイバとを結合させる光導波路部品であって、
屈折率n1のガラス基板からなり、前記ガラス基板の一部に光学的接合面が形成された下部クラッド層、及び前記ガラス基板の他の部分に前記光ファイバの固定溝が形成された光ファイバ接合部を有するベース基板と、
前記ベース基板の下部クラッド層の光学的接合面に設けられ、屈折率n2を有する紫外線硬化樹脂からなり、前記コアの空間となる溝部が前記光ファイバの固定溝の延長線上に設けられた中間クラッド層と、
前記中間クラッド層の溝部に、屈折率n3($n_3 > n_2, n_1$)を有する透明樹脂を充填し硬化させて得た前記コアと、
前記コアと中間クラッド層の上面に、屈折率n4($n_4 < n_3$)を有する平面ガラス基板を接合して形成された上部クラッド層とを有することを特徴とする光導波路部品。

【請求項5】 光ビームをコア内で拘束して前記コアの軸に沿って伝搬させる光導波路基板の製造方法であって、
屈折率n1のガラス基板を所定形状に加工して、一方の平面を光学的接合面とする下部クラッド層を得る工程と、
前記下部クラッド層の光学的接合面に、屈折率n2($n_2 > n_1$)を有する紫外線硬化樹脂を塗布する工程と、
前記コアと同一形状を有する線状凹部を形成した紫外線を透過する型を用いて前記紫外線硬化樹脂を押圧し、前記型の線状凹部を除く平面部を前記下部クラッド層の光学的接合面に当接させる工程と、
前記型の裏面より紫外線を照射することにより前記紫外線硬化樹脂を硬化させ、押圧状態から前記型を開放することにより、前記下部クラッド層の上面に前記コアを形

成する工程と、

前記コアを包み込むように屈折率 n_3 ($n_3 < n_2$) を有する透明樹脂を塗布し、硬化させることにより、平板状の上部クラッド層を形成する工程と、

前記上部クラッド層の上面に保護用平面ガラス基板を形成する工程とを有することを特徴とする光導波路基板の製造方法。

【請求項6】 光ビームをコア内で拘束して前記コアの軸に沿って伝搬させる光導波路基板であって、屈折率 n_1 の平面ガラス基板からなる下部クラッド層と、

前記下部クラッド層の上面に、屈折率 n_2 ($n_2 > n_1$) を有する紫外線硬化樹脂を用いて凸状に形成された前記コアと、

前記コアを包み込むように屈折率 n_3 ($n_3 < n_2$) を有する透明樹脂を塗布し硬化させることにより平板状に形成された上部クラッド層と、

前記上部クラッド層の上面に形成された保護用平面ガラス基板とを有することを特徴とする光導波路基板。

【請求項7】 光ビームをコア内で拘束して前記コアの軸に沿って伝搬させる光導波路基板と光ファイバとを結合させる光導波路部品の製造方法であって、屈折率 n_1 のガラス基板を所定形状に加工して、一方の平面を光学的接合面とする被成形用ガラス基板を得る工程と、

前記光ファイバの固定溝を形成するための線状山型突起が形成されたプレス型を用いて前記被成形用ガラス基板を押圧するとともに、前記被成形用ガラス基板を加熱することにより軟化させ、前記被成形用ガラス基板の一部に前記光ファイバの固定溝を形成すると共に、前記被成形用ガラス基板の他の部分に下部クラッド層を形成する工程と、

前記被成形用ガラス基板の下部クラッド層の上面に、屈折率 n_2 ($n_2 > n_1$) を有する紫外線硬化樹脂を塗布する工程と、

前記コアと同一形状を有する線状凹部を形成した紫外線を透過する型を用いて、前記線状凹部と前記光ファイバの固定溝の中心線が一致するように前記紫外線硬化樹脂を押圧し、前記型の凹部を除く平面部を前記下部クラッド層の上面に当接させる工程と、

前記型の裏面より紫外線を照射することにより前記紫外線硬化樹脂を硬化させ、押圧状態から前記型を開放することにより、前記下部クラッド層の上面に前記コアを形成する工程と、

前記コアを包み込むように屈折率 n_3 ($n_3 < n_2$) を有する透明樹脂を塗布することにより、平板状の上部クラッド層を形成する工程と、

前記上部クラッド層の上面に保護用平面ガラス基板を形成する工程とを有することを特徴とする光導波路部品の製造方法。

【請求項8】 光ビームをコア内で拘束して前記コアの軸に沿って伝搬させる光導波路基板と光ファイバとを結合させる光導波路部品であって、

屈折率 n_1 のガラス基板からなり、前記ガラス基板の一部に光学的接合面が形成された下部クラッド層、及び前記ガラス基板の他の部分に前記光ファイバの固定溝が形成された光ファイバ接合部を有するベース基板と、前記ベース基板の下部クラッド層の上面に設けられ、屈折率 n_2 ($n_2 > n_1$) を有する紫外線硬化樹脂からなり、前記光ファイバの固定溝の延長線と一致するよう凸状に形成された前記コアと、

前記コアを包み込むように屈折率 n_3 ($n_3 < n_2$) を有する樹脂を塗布し硬化させることにより、平板状に形成された上部クラッド層と、

前記上部クラッド層の上面にガラス基板を接合することにより形成された保護用平面ガラス基板とを有することを特徴とする光導波路部品。

【発明の詳細な説明】

【0001】

20 【発明の属する技術分野】 本発明は、安価な方法で製造できる高精度で信頼性の高い光導波路基板とその製造方法、及び光ファイバを接続するための光導波路部品とその製造方法に関する。

【0002】

【従来の技術】 図13は、一般的な石英系シングルモードの光導波路基板の構造を示す断面図である。この光導波路基板は、下部クラッド層121及び上部クラッド層123よりも屈折率の高いコア122aの部分に光ビームが案内されて、光ビームが光導波路の軸方向に伝搬する構成となっている。

30 【0003】 このような従来の光導波路基板の製造方法を、図14を用いて説明する。図14(a)に示すように、下部クラッド層121を兼ねた石英基板上に、火炎堆積法などを用いて、下部クラッド層121よりも屈折率の高い光学材料122を成膜し、図14(b)のような状態にする。次にフォトリソグラフ法並びにドライエッキング法により、光学材料122を所定のコアのパターンに加工し、図14(c)のようにコア122aを形成する。最後に図14(d)に示すように、コア122aを覆うよう上部クラッド層123を形成して、光導波路基板に仕上げる。このような製造方法を記載した参考文献としては、河内著、オプトロニクス、No.8、85、1988等がある。

40 【0004】 一方、樹脂材料は、石英に比べて光の透過性能や信頼性が劣るが、成形が容易である。このため光導波路基板の低コスト化を図るべく、樹脂を用いた光導波路基板も検討されている。樹脂製の光導波路基板の製造方法は、クラッド層及びコア層を順次形成し、石英製の光導波路基板の製造と同様に、コアをドライエッキング法によりパターニングして製造する。

【0005】しかしながら、コアのパターニングにフォトリソグラフ法及びドライエッチング法を用いた場合、複雑で高精度な設備が多数必要となる。従って、このような方法で光導波路基板を製造していたのでは、材料は安価であるが、実質的に光導波路基板を安価に製造することが困難である。

【0006】最近では、特開平8-320420号公報に開示されているように、図15に示したような光導波路基板の製造方法が用いられている。この製造方法では、図15(a)に示すように、ガラスのような熱可塑性材料からなる被成形物131を用い、これを加熱軟化させて平板状にする。次に図15(b)に示すように、コアパターンの反転形状(凸部)を有するプレス型でプレス成形し、冷却後に成形物を取り出す。こうするとコアパターンの転写が行われ、凹部131aが形成される。この平板状部材を光導波路基板にするには、図15(c)に示すように、屈折率の異なる樹脂132を凹部131aに埋め込む。次に図15(d)に示すように、上部クラッド層133となる基板を下部クラッド層134の上面に形成して光導波路基板を作製する。

【0007】

【発明が解決しようとする課題】しかしながら、このような転写方法では、加熱軟化した被成形物をプレス型と接触させて冷却するので、被成形物とプレス型との熱膨張係数の差に起因して熱応力が発生する。その結果、被成形物に転写されるパターンの精度が低下する。特に、プレス型の中心から外周に向けて距離が長くなるほど、パターンずれが大きくなる。特に、被成形物に樹脂材料を用いた場合は、型の材料として用いられる石英などの材料と比べると、1~2桁程度も熱膨張係数が大きいので、ひどい場合には、プレス型で樹脂材料がえぐられるようになる。

【0008】実際、本発明者が具体的に検討したところによると、プレス型を用いて樹脂基板に転写すると、ミクロンオーダのレベルで溝の幅が広がり、溝形状が乱れてしまった。この現象は、冷却時に樹脂基板がプレス型よりも大きく収縮し、樹脂基板がその転写中央部に向かって収縮した結果であると考えられる。このように、樹脂材料は低温で成形できる長所があり、製造コスト上も有利であるにもかかわらず、プレス成形によりパターンを転写しようとすると、微細なパターンを正確に転写できなくなるという問題があった。

【0009】また、光導波路基板全体を樹脂で構成した場合、熱膨張係数が大きいために、周囲の温度変化により光導波路パターンが変形し、信頼性が十分確保されなくなるという課題があった。

【0010】本発明は、このような従来の問題点に鑑みてなされたものであって、従来の熱間による成形法を用いることなく、紫外線硬化樹脂を中間クラッド層あるいはコアに用いて、熱膨張に起因する転写精度の低下を防

止し、微細パターンのコアを有する光導波路基板、光ファイバを接続するための光導波路部品、及びそれらの製造方法を実現することを目的とする。

【0011】

【課題を解決するための手段】本発明の光導波路基板は、光ビームをコア内で拘束して前記コアの軸に沿って伝搬させる光導波路基板である。また本発明の光導波路部品は、光ビームをコア内で拘束して前記コアの軸に沿って伝搬させる光導波路基板と光ファイバとを結合させる光導波路部品である。本発明の製造方法は、それらの光導波路基板あるいは光導波路部品を製造する方法である。

【0012】本発明の第1の光導波路基板の製造方法は、屈折率n1のガラス基板を所定形状に加工して、一方の平面を光学的接合面とする下部クラッド層を得る工程と、前記下部クラッド層の光学的接合面に、屈折率n2を有する紫外線硬化樹脂を塗布する工程と、前記コアと同一形状を有する線状凸部が形成された紫外線を透過する型を用いて前記紫外線硬化樹脂を押圧し、前記型の線状凸部を前記下部クラッド層の光学的接合面に当接させる工程と、前記型の裏面より紫外線を照射することにより、前記紫外線硬化樹脂を硬化させた後、前記型を離型し、前記コアの空間となる溝部が形成された中間クラッド層を得る工程と、前記中間クラッド層の前記溝部に、屈折率n3($n_3 > n_2, n_1$)を有する透明樹脂を充填して、硬化させることにより前記コアを得る工程と、前記コアが形成された後の前記中間クラッド層の上面に、屈折率n4($n_4 < n_3$)を有する平面ガラス基板を接合することにより上部クラッド層を形成する工程とを有する。

【0013】本発明の第1の光導波路基板は、屈折率n1の平面ガラス基板からなる下部クラッド層と、屈折率n4の平面ガラス基板からなる上部クラッド層と、前記下部クラッド層と前記上部クラッド層とに挟持され、屈折率n2を有する紫外線硬化樹脂からなり、前記コアの空間となる溝部が設けられた中間クラッド層と、前記中間クラッド層の溝部に、屈折率n3($n_3 > n_4, n_2, n_1$)を有する透明樹脂を充填し硬化させて得た前記コアとを有する。

【0014】本発明の第1の光導波路部品の製造方法は、屈折率n1のガラス基板を所定形状に加工して、一方の平面を光学的接合面とする被成形用ガラス基板を得る工程と、前記光ファイバの固定溝を形成するための線状山型突起が形成されたプレス型を用いて前記被成形用ガラス基板を押圧するとともに、前記被成形用ガラス基板を加熱することにより軟化させ、前記被成形用ガラス基板の一部に前記固定溝を形成するとともに、前記被成形用ガラス基板の他の部分に下部クラッド層を形成する工程と、前記被成形用ガラス基板の下部クラッド層の上面に、屈折率n2を有する紫外線硬化樹脂を塗布する工

程と、前記コアと同一形状を有する線状凸部が形成された紫外線を透過する型を用いて、前記線状凸部と前記光ファイバの固定溝の中心線が一致するように前記紫外線硬化樹脂を押圧し、前記型の線状凸部を前記被成形用ガラス基板の下部クラッド層の平面部分に当接させる工程と、前記型の裏面より紫外線を照射することにより前記紫外線硬化樹脂を硬化させた後、前記型を開放し、前記コアの空間となる溝部が形成された中間クラッド層を得る工程と、前記中間クラッド層の溝部に、屈折率 n_3 ($n_3 > n_2, n_1$) を有する透明樹脂を充填して硬化させることにより前記コアを得る工程と、前記コアが形成された後の中間クラッド層の上面に、屈折率 n_4 ($n_4 < n_3$) を有する平面ガラス基板を接合することにより上部クラッド層を形成する工程とを有する。

【0015】本発明の第1の光導波路部品は、屈折率 n_1 のガラス基板からなり、前記ガラス基板の一部に光学的接合面が形成された下部クラッド層、及び前記ガラス基板の他の部分に前記光ファイバの固定溝が形成された光ファイバ接合部を有するベース基板と、前記ベース基板の下部クラッド層の光学的接合面に設けられ、屈折率 n_2 を有する紫外線硬化樹脂からなり、前記コアの空間となる溝部が前記光ファイバの固定溝の延長線上に設けられた中間クラッド層と、前記中間クラッド層の溝部に、屈折率 n_3 ($n_3 > n_2, n_1$) を有する透明樹脂を充填し硬化させて得た前記コアと、前記コアと中間クラッド層の上面に、屈折率 n_4 ($n_4 < n_3$) を有する平面ガラス基板を接合して形成された上部クラッド層とを有する。

【0016】本発明の第2の光導波路基板の製造方法は、屈折率 n_1 のガラス基板を所定形状に加工して、一方の平面を光学的接合面とする下部クラッド層を得る工程と、前記下部クラッド層の光学的接合面に、屈折率 n_2 ($n_2 > n_1$) を有する紫外線硬化樹脂を塗布する工程と、前記コアと同一形状を有する線状凹部を形成した紫外線を透過する型を用いて前記紫外線硬化樹脂を押圧し、前記型の線状凹部を除く平面部を前記下部クラッド層の光学的接合面に当接させる工程と、前記型の裏面より紫外線を照射することにより前記紫外線硬化樹脂を硬化させ、押圧状態から前記型を開放することにより、前記下部クラッド層の上面に前記コアを形成する工程と、前記コアを包み込むように屈折率 n_3 ($n_3 < n_2$) を有する透明樹脂を塗布し硬化させることにより、平板状の上部クラッド層を形成する工程と、前記上部クラッド層の上面に保護用平面ガラス基板を形成する工程とを有する。

【0017】本発明の第2の光導波路基板は、屈折率 n_1 の平面ガラス基板からなる下部クラッド層と、前記下部クラッド層の上面に、屈折率 n_2 ($n_2 > n_1$) を有する紫外線硬化樹脂を用いて凸状に形成された前記コアと、前記コアを包み込むように屈折率 n_3 ($n_3 < n_2$) を有する透明樹脂を塗布し硬化させることにより、平板状の上部クラッド層を形成することにより形成された保護用平面ガラス基板とを有する。

2) を有する透明樹脂を塗布し硬化させることにより平板状に形成された上部クラッド層と、前記上部クラッド層の上面に形成された保護用平面ガラス基板とを有する。

【0018】本発明の第2の光導波路部品の製造方法は、屈折率 n_1 のガラス基板を所定形状に加工して、一方の平面を光学的接合面とする被成形用ガラス基板を得る工程と、前記光ファイバの固定溝を形成するための線状山型突起が形成されたプレス型を用いて前記被成形用ガラス基板を押圧するとともに、前記被成形用ガラス基板を加熱することにより軟化させ、前記被成形用ガラス基板の一部に前記光ファイバの固定溝を形成すると共に、前記被成形用ガラス基板の他の部分に下部クラッド層を形成する工程と、前記被成形用ガラス基板の下部クラッド層の上面に、屈折率 n_2 ($n_2 > n_1$) を有する紫外線硬化樹脂を塗布する工程と、前記コアと同一形状を有する線状凹部を形成した紫外線を透過する型を用いて、前記線状凹部と前記光ファイバの固定溝の中心線が一致するように前記紫外線硬化樹脂を押圧し、前記型の凹部を除く平面部を前記下部クラッド層の上面に当接させる工程と、前記型の裏面より紫外線を照射することにより前記紫外線硬化樹脂を硬化させ、押圧状態から前記型を開放することにより、前記下部クラッド層の上面に前記コアを形成する工程と、前記コアを包み込むように屈折率 n_3 ($n_3 < n_2$) を有する透明樹脂を塗布することにより、平板状の上部クラッド層を形成する工程と、前記上部クラッド層の上面に保護用平面ガラス基板を形成する工程とを有する。

【0019】本発明の第2の光導波路部品は、屈折率 n_1 のガラス基板からなり、前記ガラス基板の一部に光学的接合面が形成された下部クラッド層、及び前記ガラス基板の他の部分に前記光ファイバの固定溝が形成された光ファイバ接合部を有するベース基板と、前記ベース基板の下部クラッド層の上面に設けられ、屈折率 n_2 ($n_2 > n_1$) を有する紫外線硬化樹脂からなり、前記光ファイバの固定溝の延長線と一致するよう凸状に形成された前記コアと、前記コアを包み込むように屈折率 n_3 ($n_3 < n_2$) を有する樹脂を塗布し硬化させることにより、平板状に形成された上部クラッド層と、前記上部クラッド層の上面にガラス基板を接合することにより形成された保護用平面ガラス基板とを有する。

【0020】

【発明の実施の形態】以下、本発明の各実施の形態について図面を参照しながら説明する。

【0021】(実施の形態1) 本発明の実施の形態1における光導波路基板の構造とその製造方法について、図1～図4を用いて説明する。光導波路基板とは、光ビームをコア内で拘束してコアの軸に沿って伝搬させるものである。図1は、本実施の形態における光導波路基板の製造方法の概略工程図である。図1(a)に示すよう

に、屈折率 n_1 の平面ガラス基板からなる下部クラッド層 1 1 を水平に固定し、図 1 (b) に示すように紫外線硬化樹脂 1 2 を、下部クラッド層 1 1 の光学的接合面である上面に塗布する。この紫外線硬化樹脂 1 2 は、屈折率 n_2 を有するものである。

【0022】次に、コアに相当する位置に、線状凸部を有する紫外線を透過する型 (図示せず) を予め作成しておき、その型で紫外線硬化樹脂 1 2 を押圧し、型の裏面より紫外線を照射することにより、紫外線硬化樹脂 1 2 を硬化させ、型を離型する。そうすると、図 1 (c) に示すように、コアと同一厚みで、コアに相当する溝部 1 4 を有する中間クラッド層 1 3 が形成される。そして図 1 (d) に示すように、溝部 1 4 に屈折率 n_3 ($n_3 > n_2, n_1$) の透明樹脂を充填し、コア 1 5 を形成する。その上に、図 1 (e) に示すように、屈折率 n_4 ($n_4 < n_3$) を有する平面ガラス基板からなる上部クラッド層 1 6 を設け、光導波路基板が完成する。

【0023】図 2 は、本実施の形態の製造方法に於いて、紫外線硬化樹脂 1 2 の硬化工程に用いる紫外線照射装置 2 0 を示す断面図である。図 2 は、硬化前の状態を示す。紫外線を透過する型 2 1 は、コアを形成するための線状凸部 2 1 a を有する石英製の型である。この線状凸部 2 1 a は、本実施の形態に基く実施例では、厚さ 5 mm、縦 5 mm × 横 5 mm の石英ガラス基板を平面に研磨した後、通常のフォトレジストを用いたパターニング法により形成した。実施例では、石英ガラス基板に対して帯状のパターンを形成した後、ドライエッキング法を用いて石英ガラス基板表面に、線状凸部 2 1 a (断面形状；高さ 8 μ m × 幅 8 μ m の突起) を 250 μ m 間隔で 4 本設けた。

【0024】一方、下部クラッド層 1 1 として用いた平面ガラス基板は、厚さ 2 mm、縦 5 mm × 横 5 mm の平面に研磨したもので、屈折率 $n_1 = 1.5$ 、熱膨張係数 $70 \times 10^{-7} / K$ の特性を有している。この下部クラッド層 1 1 に n_1 と同じ屈折率 n_2 を有する紫外線硬化樹脂 1 2 を、スピンドルコーティングにより均一の厚みで塗布した。続いて、前述した石英製の型 2 1 に離型剤を塗布した後、紫外線硬化樹脂 1 2 上に型 2 1 を載せて、下ブロック 2 2 上に置いた。

【0025】この状態で、紫外線を発生する光源 2 4 を内蔵した上ブロック 2 3 を徐々に下降させ、圧力を加えて押圧した。図 3 に示すように、石英製の型 2 1 の線状凸部 2 1 a の先端が、下部クラッド層 1 1 の表面に接するまで押圧を続け、型 2 1 の裏面より紫外線を照射し、紫外線硬化樹脂 1 2 を硬化させた後、型 2 1 を離型させた。このときの基板は図 3 に示すように、下部クラッド層 1 1 上に、コアと同一厚みで、コアに相当する溝部を有する中間クラッド層 1 3 が形成された。この基板では、中間クラッド層 1 3 がコアで互いに分離されて帯状になっている。さらに帯状の中間クラッド層 1 3 は、下

部クラッド層 1 1 に強固に接着されているので、型 2 1 と中間クラッド層 1 3 とのパターンずれが非常に小さくなり、型 2 1 の形状がそのまま良好に転写されたものとなる。

【0026】引き続いて、図 1 (c)、(d) に示すように、形成された溝部 1 4 に、中間クラッド層 1 3 よりも 0.3% 程度高い屈折率 n_3 を有するエポキシ製の透明樹脂を埋め込み、図 1 (d) のようにコア 1 5 を形成した。そして更にその上部から下部クラッド層 1 1 と同一の平面ガラス基板からなる上部クラッド層 1 6 を貼り合わせた。このようにして、図 4 に示す光導波路基板を作製した。

【0027】この光導波路基板は、エポキシ樹脂をコア 1 5 とし、平面ガラス基板を上部クラッド層 1 6 及び下部クラッド層 1 1 とし、紫外線硬化樹脂を中間クラッド層 1 3 として備えている。このように上下のクラッド層の平面ガラス基板により、透明樹脂からなるコア 1 5 と中間クラッド層 1 3 を強固に挟み込む構造となっている。このため、周囲環境の温度変化によって形状変化がほとんど生じないことが判った。従って、この光導波路基板は十分な実用性を備えているといえる。

【0028】(実施の形態 2) 次に本発明の実施の形態 2 における光導波路部品の構造とその製造方法について、図 5 及び図 6 を用いて説明する。光導波路部品とは、光ビームをコア内で拘束してコアの軸に沿って伝搬させる光導波路基板と、光ファイバとを結合させる部品である。まず超硬合金素材を用いてプレス型 (図示せず) を製作する。プレス型には、光ファイバを固定する V 字状の固定溝と、光導波路基板を形成するための平面部 (光学的接合面) とを一体化するようなプレス面が必要である。このため、固定溝を形成するための複数の線状山型突起と、線状山型突起に隣接した平面部とが同時に形成されるよう、硬合金素材に加工を施す。本実施の形態に基く実施例では、外形寸法が厚さ 10 mm、縦 10 mm × 横 5 mm とし、線状山型突起の間隔は 250 μ m で 4 本形成した。このプレス型のプレス面に離型用保護膜として貴金属合金膜を成膜した。

【0029】次に図 5 (a) に示すように、ベース基板用の被成形用ガラス基板 5 0 (例えば屈折率 $n_1 = 1.5$ 、熱膨張係数 $70 \times 10^{-7} / K$ 、厚さ 2 mm、縦 10 mm × 横 5 mm) を用意し、前述したプレス型 (図示せず) の下に被成形用ガラス基板 5 0 が位置するよう固定する。次に被成形用ガラス基板 5 0 とプレス型とを加熱し、被成形用ガラス基板 5 0 を例えば 700 °C で加熱軟化させてプレス成形を行う。この結果、図 5 (b) に示すように、光ファイバを固定するための V 字状の固定溝 5 1 が光ファイバ接合部として形成され、下部クラッド層の光学的接合面となる平面部 5 2 と一体化されたベース基板 5 3 が形成される。

【0030】次に、予めコア部分に相当する線状凸部を

有する紫外線を透過する型（図示せず）を、以下のように作製する。例えば、厚さ5mm、縦5mm×横5mmの石英ガラス基板を平面に研磨した後、通常のフォトレジストを用いたパターニング法により、コア部分のパターンを形成する。そして、ドライエッチング法を用いて石英ガラス基板の表面であってコアに相当する位置に、線状凸部（断面形状；高さ8μm×幅8μmの突起）を250μm間隔で4本形成する。

【0031】次に図5（b）、（c）に示すように、ベース基板53の平面部52に、屈折率n2（n2=n1）の紫外線硬化樹脂54をスピンドルコートにより塗布する。そして紫外線を透過する型の表面に離型剤を塗布し、図2に示す紫外線硬化樹脂の硬化工程に用いた紫外線照射装置20に設置する。このとき、固定溝51の中心線と線状凸部の中心線が一致するように、紫外線を透過する型21をガイドを用いて固定する。この状態で、上ブロック23、下ブロック22の間に設置し、上ブロック23を徐々に下降させ、圧力を加えて押圧する。図2に示したような型21の線状凸部21aの先端が、図5（d）に示すように、ベース基板53における下部クラッド層59となる部分の表面に接するまでプレスを続ける。

【0032】そしてそのままの状態で型の裏面から、上ブロック23に内蔵した紫外線の光源24を点灯し、紫外線を照射して紫外線硬化樹脂54を硬化させ、型21を離型させる。その結果図5（d）に示すように、下部クラッド層59の上面に、コアと同一厚みで、コア部分に相当する溝部55aを有する中間クラッド層55が形成される。

【0033】引き続いて、形成された溝部55aに対して、図6（e）に示すように紫外線硬化樹脂54よりも屈折率が0.3%程度高い屈折率n3を有するエポキシの透明樹脂を埋め込んでコア56を形成する。更にその上部から、図6（f）に示すように、屈折率n4（n4=n1）の平面ガラス基板を上部クラッド層57として貼り合わせ、ベース基板53に光ファイバ接合部と光導波路基板とを合体した状態とする。このようにして光ファイバ接合部と、下部クラッド層59、中間クラッド層55、コア56、上部クラッド層57からなる光導波路基板とを有する光導波路部品を作製した。

【0034】本実施の形態の製造方法により作製した光導波路部品では、帯状の中間クラッド層55がコア56を介して互いに分離され、更に下部クラッド層59に強固に接着されている。このため、紫外線を透過する型と中間クラッド層55と、コア56の材料との収縮差によるパターンずれが非常に小さくなり、紫外線を透過する型の形状をそのまま良好に転写することができる。しかも、光ファイバを固定するためのV字状の固定溝51が、光導波路基板のコアと高精度に位置合わせされているので、光ファイバを固定溝に並べるだけで、容易に光

導波路部品を分波器等に組み込むことができる。

【0035】（実施の形態3）次に本発明の実施の形態3における光導波路基板の構造とその製造方法について、図7～図10を用いて説明する。図7は光導波路基板の製造方法を示す工程図である。図7（a）に示すように、屈折率n1の平面ガラス基板からなる下部クラッド層71を用意する。次に図7（b）に示すように、下部クラッド層71の光学的接合面に屈折率n2（n2>n1）の紫外線硬化樹脂72をスピンドルコートにより塗布する。

【0036】一方、コア部分に相当する位置に線状凹部が形成された紫外線を透過する型（図示せず）を用意し、紫外線硬化樹脂72を型で押圧し、型の裏面より紫外線を照射して、紫外線硬化樹脂を硬化させて、図7（c）のように互いに独立した帯状のコア73を複数本形成する。次に図7（d）に示すように、コア73の部分を包み込むように屈折率n3（n3<n2）を有する樹脂を塗布することにより、上部クラッド層74を形成する。そして図7（e）に示すように、上部クラッド層74上に保護用平面ガラス基板75を接合することにより、構造の光導波路基板が得られる。

【0037】図8は、本実施の形態の製造方法に於いて、紫外線硬化樹脂の硬化工程に用いる紫外線照射装置80の構造を示す断面図であり、硬化前の状態を示す。この紫外線照射装置80は、実施の形態1の紫外線照射装置と同様に、上下動可能な上ブロック81と、固定の下ブロック82を有し、上ブロック81には、紫外線を発生する光源84が内蔵されている。

【0038】紫外線を透過する型83は、コア部分に相当する位置に線状凹部83aを有するものである。この線状凹部83aは、実施例では、厚さ5mm、縦5mm×横5mmの石英ガラス基板を平面に研磨した後、通常のフォトレジストを用いたパターニング法により形成された。また、石英ガラス基板に対して帯状のパターンを形成した後、ドライエッチング法を用いて石英ガラス基板表面に線状凹部83a（断面形状；深さ8μm×幅8μmの突起）を250μm間隔で4本設けた。

【0039】次に厚さ2mm、縦5mm×横5mmの平面に研磨した平面ガラス基板（屈折率n1=1.5、熱膨張係数70×10⁻⁷/K、耐熱温度700°C）を下部クラッド層71として用意し、下ブロック82に載置した。そして屈折率がn1より0.3%程度高い屈折率n2を有する紫外線硬化樹脂72を平面ガラス基板の上面に、スピンドルコートにより塗布した。続いて、前述した石英ガラス製の型83を紫外線硬化樹脂72の上面に載せた。図8はこの状態を示す。

【0040】次に、上ブロック81を徐々に下降させて圧力を加えて押圧した。図9に示すように、石英ガラス製の型83の先端が、下部クラッド層71を形成する平面ガラス基板の表面に接するまで押圧を続け、紫外線の

光源を点灯させ、型83の裏面より、紫外線を照射した。紫外線硬化樹脂72が硬化したところで、型83を離型した。この状態で図7(c)に示したように下部クラッド層71上に4本のコア73が形成された。実施例では、各コア73が250μm間隔で分離され、更に下部クラッド層71に強固に接着された。このため、紫外線を透過する型83とコア材料とのパターンずれが非常に小さくなり、型83の形状をそのまま良好に転写することができた。

【0041】引き続いて、下部クラッド層71と同一屈折率を有するエポキシ樹脂をコア73を包み込むように塗布して上部クラッド層74とし、更にその上部から保護用平面ガラス基板75を貼り合わせ、図10に示すような光導波路基板を作製した。

【0042】この光導波路基板は、樹脂を上部クラッド層74とし、平面ガラス基板を下部クラッド層71とし、紫外線硬化樹脂をコア73とし、更に、上部クラッド層74の上に保護用平面ガラス基板75を備えた構造となっている。このように上下の平面ガラス基板により、エポキシ樹脂からなる上部クラッド層74を強固に挟み込んでいるので、周囲環境の温度変化による形状変化はほとんど生じないことが判った。従って、この光導波路基板は十分な実用性を備えていると言える。

【0043】(実施の形態4) 次に本発明の実施の形態4における光導波路部品の構造とその製造方法について、図11及び図12を用いて説明する。まず、超硬合金素材を用いてプレス型(図示せず)を製作する。プレス型には、光ファイバを固定するためのV字状の固定溝と、光導波路基板を形成するための平面部とを一体化するようプレス面を形成しなければならない。実施例で用意したプレス型は、超硬合金素材に加工を施し、V字状の固定溝に対する型として線状山型突起を複数本形成し、更に、その横に平面部を形成したものであった。プレス型の外形は厚さ10mm、縦10mm×横5mmの寸法を有するものとし、線状山型突起の間隔は250μmで4本形成した。このプレス型のプレス面に離型用保護膜として貴金属合金膜を成膜した。

【0044】次に図11(a)に示すように、被成形用ガラス基板110(屈折率n1=1.5、熱膨張係数7.0×10⁻⁷/K、厚さ2mm、縦10mm×横5mm)を用意し、前述したプレス型の下方に固定した。そしてプレス型を加熱し、被成形用ガラス基板110を750℃で加熱軟化させてプレス成形を行った。この結果、図11(b)に示すように、光ファイバを固定するためのV字状の固定溝111と、光導波路基板を形成するための平面部112とが一体化されたベース基板113が形成された。

【0045】次に、予めコア部分に相当する位置に線状凹部を有する紫外線を透過する型(図示せず)を以下の方法で作製した。厚さ5mm、縦5mm×横5mmの石

英ガラスの基板を平面に研磨した後、通常のフォトレジストを用いたパターニング法により、コア部分が溝となるパターンを形成した。そして、ドライエッチング法を用いて石英ガラス基板の表面であって、コアに相当する位置に線状凹部(断面形状:深さ8μm×幅8μmの突起)を250μm間隔で4本形成した。

【0046】次に図11(b)、(c)に示すように、ベース基板113の平面部112(光学的接合面)上に、n1より0.3%程度高い屈折率n2の紫外線硬化樹脂114をスピンドルコーティングにより塗布した。

10 そして線状凹部を有する紫外線を透過する型の表面に離型剤を塗布し、図8に示した紫外線照射装置80にセットした。このとき、固定溝111の中心線と溝部の中心線が一致するように紫外線を透過する型をガイドを用いて固定した。この状態で、下ブロック82の上面に載置し、上ブロック81を徐々に下降させ、圧力を加えて押圧した。図8に示す石英ガラス製の型83の先端面が、図11(d)に示すベース基板113の下部クラッド層116の部分の表面に接するまで押圧を続けた。

20 【0047】そしてそのままの状態で、紫外線の光源84を点灯させ、石英ガラス製の型83の裏面より、紫外線を照射し、紫外線硬化樹脂114を硬化させ、コア115を形成し、型83を離型した。この結果、図11(d)に示すように、下部クラッド層116の光学的接合面に4本のコア115が形成された。

【0048】引き続いて取り出した基板全体に対して、図12(e)に示すように、下部クラッド層116と同一屈折率n3のエポキシの樹脂をコア115を包み込むように塗布して上部クラッド層117を形成した。更に

30 その上部から保護用平面ガラス基板118を貼り合わせ、図12(f)に示すように、光ファイバ接合部と、下部クラッド層116、コア115、上部クラッド層117からなる光導波路基板とを有する光導波路部品を作製した。

【0049】本実施の形態の製造方法により作製した光導波路部品は、図12(f)に示すように、4本のコア115が互いに分離され、更に下部クラッド層116に強固に接着されている。このため、紫外線を透過する型とコア材料とのパターンずれが非常に小さくなり、紫外線を透過する型の形状をそのまま良好に転写することができる。しかも、光ファイバを固定するためのV字状の固定溝111が高精度に光導波路基板のコアと位置合わせされる。このため、光ファイバを固定溝111に並べるだけで、容易に光導波路部品を分波器等に組み込むことができる。

【0050】

【発明の効果】本発明によれば、紫外線を透過する型と紫外線硬化樹脂の間では、紫外線照射による紫外線硬化樹脂の硬化工程で発生する収縮によるパターンずれを著50 しく小さくできるため、効率良く精度の高いコアペー

ンの形成が可能となる。従って、安価な光導波路基板及び光導波路部品を効率よく製造することができる。また、本発明の光導波路基板及び光導波路部品は、周囲温度の変化に対する形状変化が小さくなり、非常に信頼性の高いものが得られる。

【図面の簡単な説明】

【図1】本発明の実施の形態1における光導波路基板の製造方法の概略工程を示す断面図

【図2】実施の形態1の光導波路基板の製造に用いられる紫外線照射装置において、紫外線を透過する型をセットした状態を示す概略断面図

【図3】実施の形態1の光導波路基板の製造に用いられる紫外線照射装置において、紫外線硬化樹脂の硬化工程が完了した状態を示す概略断面図

【図4】実施の形態1の製造方法で製造された光導波路基板の断面構成図

【図5】本発明の実施の形態2における光導波路部品の製造方法の概略工程(その1)を示す斜視図

【図6】実施の形態2における光導波路部品の製造方法の概略工程(その2)を示す斜視図

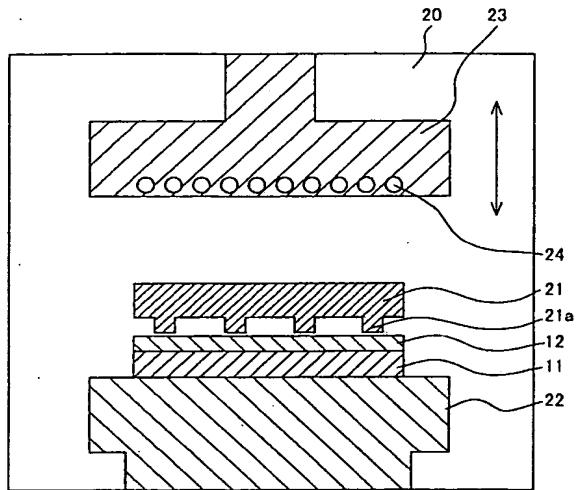
【図7】本発明の実施の形態3における光導波路基板の製造方法の概略工程を示す断面図

【図8】実施の形態3の光導波路基板の製造に用いられる紫外線照射装置において、紫外線を透過する型をセットした状態を示す概略断面図

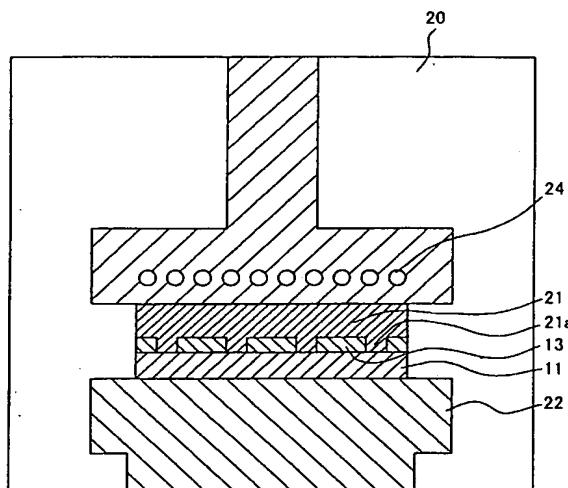
【図9】実施の形態3の光導波路基板の製造に用いられる紫外線照射装置において、紫外線硬化樹脂の硬化工程が完了した状態を示す概略断面図

【図10】実施の形態3における光導波路基板の断面構

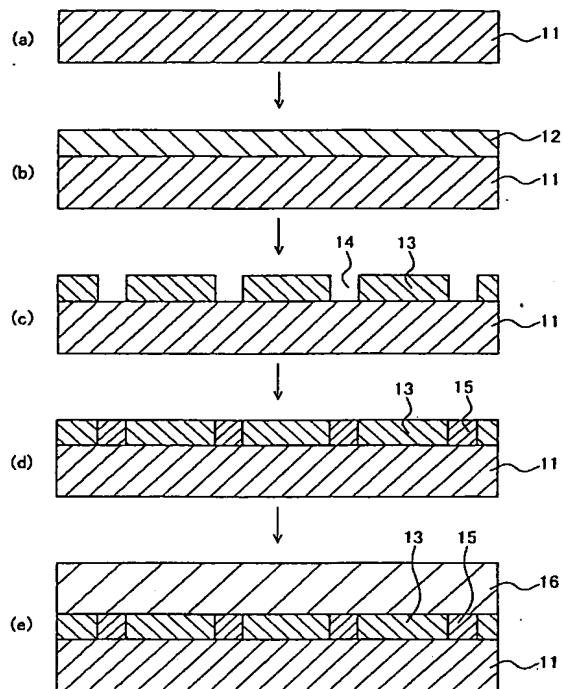
【図2】



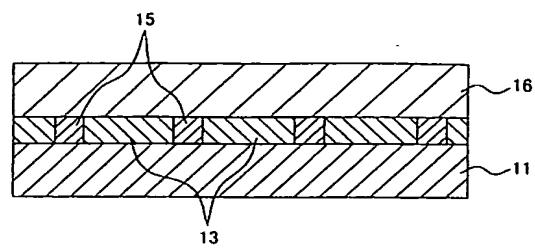
【図3】



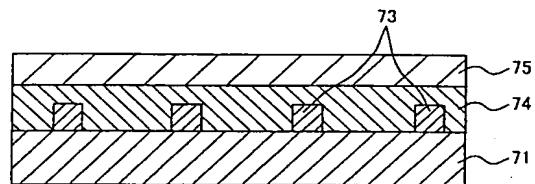
【図1】



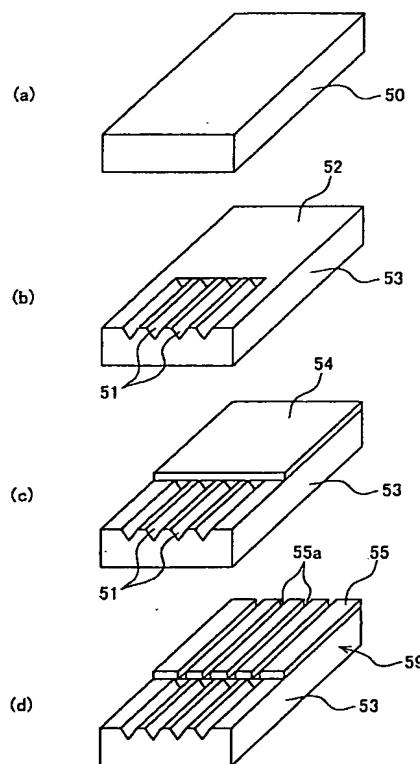
【図4】



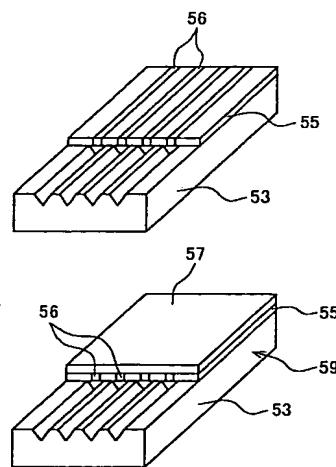
【図10】



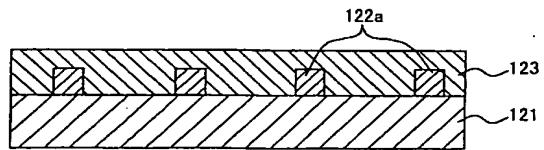
【図5】



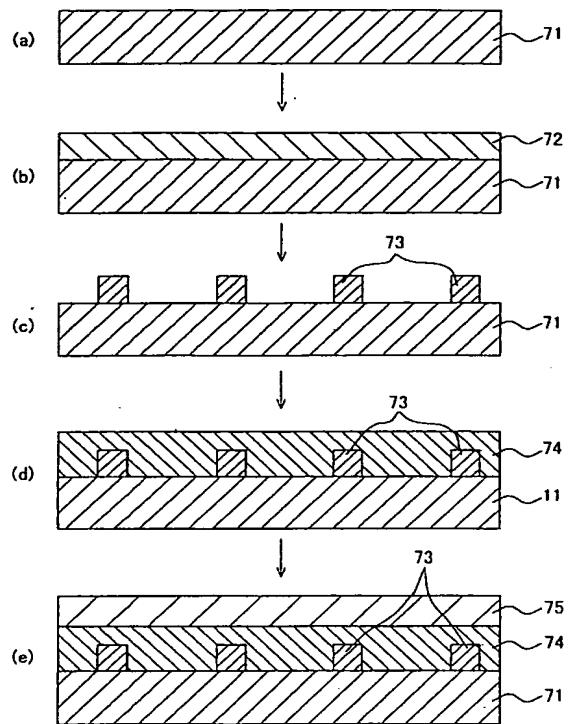
(e)



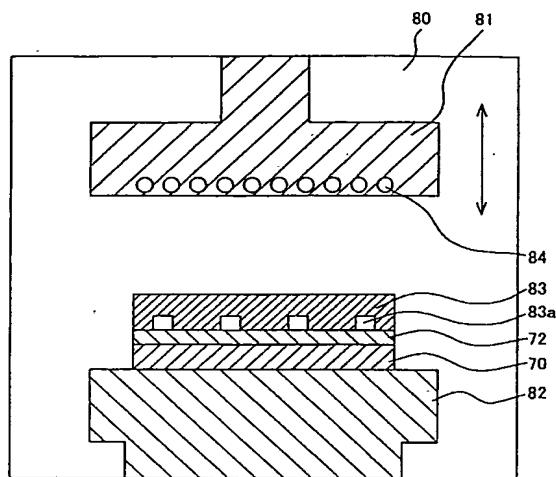
【図13】



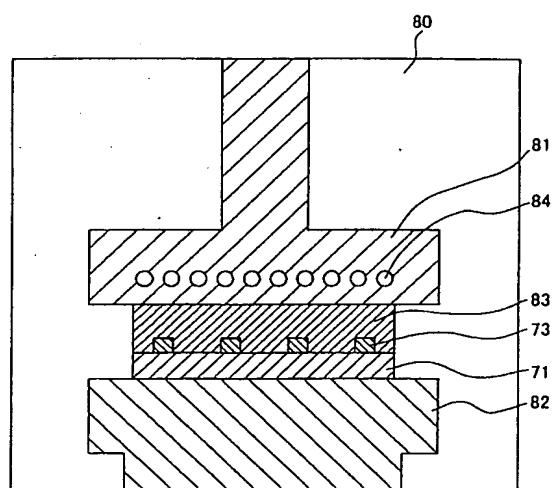
【図7】



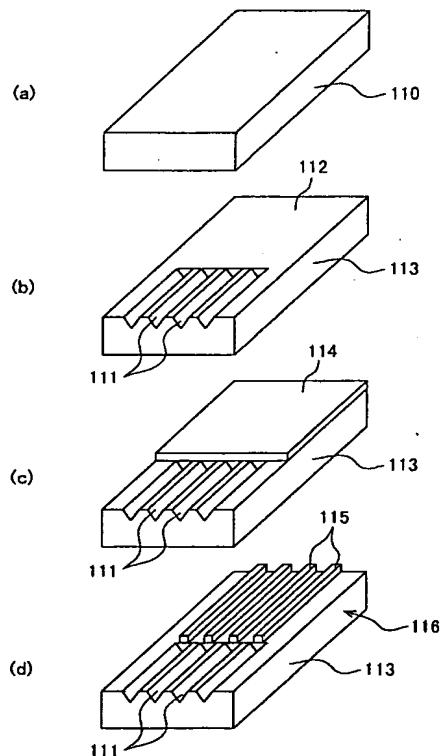
【図8】



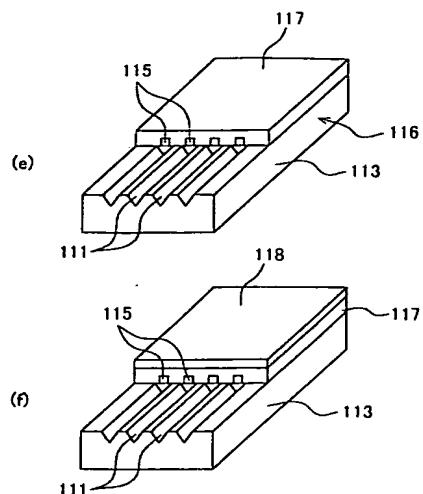
【図9】



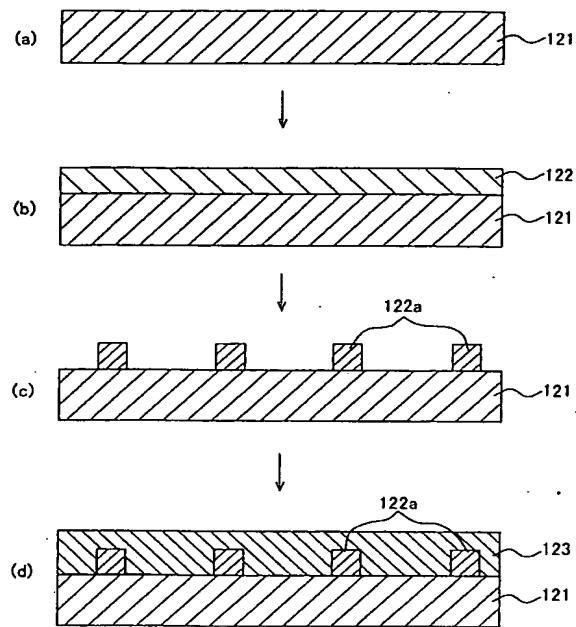
【図11】



【図12】



【図14】



【図15】

